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Hardy Corn Varieties Developed for Drought and Acidic Soils
Could Raise Yields 40 Percent and Help Feed Developing World

Researchers have created hardy new breeds of tropical corn that can increase harvests by 40 percent in the tough environments of the developing world, says a new report by the International Maize and Wheat Improvement Center, known as CIMMYT.

The new corn varieties were specifically developed to overcome two typical growing constraints in the tropics: periodic droughts and highly acidic soils.

The new breeds of corn, if planted widely, could feed an additional 50 million people yearly, says CIMMYT, which conducts research in more than 100 countries. The new corn will also help the environment by allowing farmers in the developing world to stay on what was becoming non-productive lands, thereby saving virgin rain forests and other fragile tropical lands.

Of the 320 million acres (129 million hectares) planted in corn worldwide, 150 million acres -- an area about the size of Texas -- are in the tropics and subtropics, mostly in developing countries.

"As the world's population continues to grow, so does the need to feed it -- and the need to continue research into ways to produce more food from dwindling agricultural land without further damaging the fragile environment," says Ismail Serageldin, Chairman of CGIAR, the Consultative Group on International Agricultural Research. CIMMYT is one of 18 research centers in the CGIAR system.

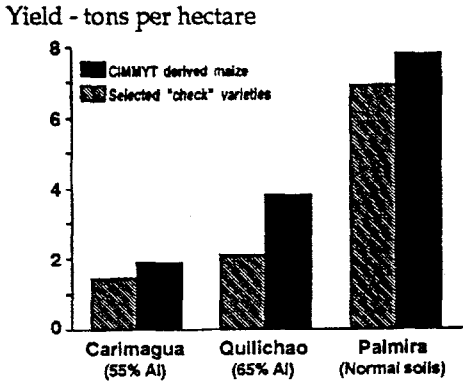
Corn, more generally known as maize, is native to the Western Hemisphere, but has become one of the most important crops in both the developed and developing world.

"Maize grows marvelously in the temperate climates of North America and Western Europe, producing an average of seven tons per hectare (2.47 acres), compared with an average of just 2.5 tons per hectare for farmers in the developing world," says Gregory Edmeades, Ph.D., in charge of CIMMYT's Maize Sub-Program in Mexico.

"But even that 2.5-ton average conceals the true circumstances faced by many farmers in the developing world, who often get considerably less yield because of periodic droughts and because of the widespread incidence of highly acidic soils in the tropics," says Dr. Edmeades.

One half of the 60 million hectares (148 million acres) planted in corn in the developing world is subject to periodic droughts. Some 13 million hectares (32 million acres) are located in Latin America, 7 million (17 million acres) in Africa and 8 million (19.8 million acres) in Asia.

Drought caused the loss of an estimated 24 million tons of corn in 1993 in the developing world, a drop of 15 percent from the potential crop without any drought.



Comparison of CIMMYT maize varieties with outstanding national program materials at three locations in Colombia.

Nearly 20 million acres (eight million hectares) of maize are planted in acidic soils -- 7.5 million acres (three million hectares) in South America; six million acres (2.5 million hectares) in Asia; 3.7 million acres (1.5 million hectares) in Africa; and about 2.5 million acres (one million hectares) in Central America, Mexico and the Caribbean.

Acid soils cover a total of more than four billion acres (1.66 billion hectares) in 48 developing countries. More than 40 percent of the world's tropical land area is classified as acidic, comprising more than 60 percent of tropical South America, nearly 40 percent of tropical Asia, 30 percent of tropical Africa and 10 percent of Central America, the Caribbean and Mexico.

More than 80 percent of the area used for agriculture in tropical South America has soils with acid characteristics. The area under *cerrado* vegetation in Brazil occupies some 450 million acres (180 million hectares), or about 20 percent of the total area of the country.

In Africa, nearly half of the land is covered by acid soils in countries like Zaire, Zambia and Cote d'Ivoire. In East Africa, Uganda, Zimbabwe and Tanzania have sizable areas under acid soils.

Asian nations with soil acidity problems include Indonesia, Thailand, Malaysia, India, China and the Philippines.

Drought Resistant Corn

Drought interrupts the key stage in corn growth -- when the male flower, called the tassel, on top of the stalk, pollinates a part of the female flower called the silks, borne near the middle of the stalk. Those silks are attached to florets that, when fertilized, develop into grains of corn.

During drought, the tassel usually wins the competition with the silks for the carbohydrates that feed the plant, thereby stunting or preventing the formation of grain, and yields can drop to zero. To develop a drought-resistant corn, CIMMYT researchers began selective breeding with the "Tuxpeño" variety that was already well adapted to tropical lowlands.

Researchers bred this drought-tolerant Tuxpeño corn under drought conditions, selecting, at flowering, those plants where the silks appeared soon after the male flower emerged. When tassel and silk development most nearly coincided, grain production was highest. The selected plants were then bred further over an eight-year period, in order to achieve even greater drought tolerance.

Scientists found that such plants allocate more carbohydrates, or energy, to the ear, which allows the plant to produce more grain with less moisture. This selective breeding led to the "Tuxpeño Sequia" variety and others like it, which can be grown under a wider range of tropical conditions.

"We cannot predict droughts, so we must develop a corn that grows well in both drought and non-drought conditions," says Mr. Serageldin. "The new breeds also show up to 10-percent increase in yield during non-drought seasons."

The experiments were carried out in the cool, virtually rain-free winter crop season near CIMMYT headquarters in Mexico, where timing and intensity of stress were managed by irrigation.

Each of 250 corn lines was grown in single-row plots under three degrees of increasing drought conditions: well-watered; intermediate stress, where water was withdrawn during late flowering and throughout grain filling; and severe stress, where no water is applied beginning approximately three weeks before the silks are due to emerge.

The research has already produced new varieties that, in times of severe mid-season droughts, produce 2.8 tons per hectare, a 40 percent increase over regular maize yields under similar drought conditions, the report says.

The improved varieties have now been sent out for further field testing to 22 countries that suffer periodic droughts. CIMMYT believes that as many as 20 developing countries in the next 10 years can begin full-scale production of drought-tolerant corn.

"Drought tolerance research in maize is producing ever more water-efficient plants, which is another way of saying we're now getting more grain production with less water," says Dr. Edmeades. "For that reason, we believe this work -- which is aimed at helping desperately poor maize farmers -- is wholly consistent with the world community's broader concerns about a better use of environmental resources."

Corn for Acidic Soils

Aluminum is the most harmful ingredient to corn in acid soils. It interferes with cell division in the root tips and lateral roots of corn, increases cell wall rigidity and reduces DNA replication. Aluminum also decreases root respiration and weakens the uptake, transport and use of essential elements, even when the root zone is moist. It also causes phosphorus, an essential plant nutrient, to be fixed in less available forms in the soil and on the surface of roots.

Researchers now have evidence that the roots of corn plants that are tolerant to acid soil exude more citric acid than other plants. This citric acid binds with the aluminum to form a new substance that is harmless to the plant.

To develop strains for acidic soils, CIMMYT researchers over the past 10 years selected several hundred varieties from a broad array of international maize germplasm, which they evaluated under a range of acid soil conditions in Colombia, Brazil, Peru, Venezuela and Indonesia. In addition, one set of all varieties was also grown on normal soils in Colombia to ensure high productivity under relatively normal fertility conditions.

"As with corn varieties we've developed for drought, the new corn breeds for acidic soils also increase yields in land that has no acidity problem, which we call non-stress environments," says Charles Wedderburn, Ph.D., associate director of CIMMYT's Maize Program. "In other words, tolerance to soil acidity does not necessarily mean lower performance under high management conditions."

Based on their performance, six acid-tolerant maize varieties were developed and are still being improved, with different grain colors and textures, in collaboration with the governments of Colombia, Brazil, Peru, Venezuela and Indonesia.

Distribution of acid soils

The specially bred corn increases yields by one-half ton per hectare, an increase of 40 percent. CIMMYT researchers, while still trying to selectively breed more powerful acid-tolerant corn, have begun sending out varieties to several countries for final testing.

"Development of genetically acid soil-tolerant maize varieties offers an ecologically clean, energy-conserving and cost-effective way to increase maize yields in these areas," says Mr. Serageldin. "It would permit sustainable maize cropping systems to be established on acidic savanna and reduce the pressure to farm marginal forest and hillside lands. All of this would help reduce deterioration of fragile agricultural lands and ease the pressure to cut down tropical rain forests to obtain additional farmland."

Background

CIMMYT (the Spanish acronym for **Centro Internacional de Mejoramiento de Maiz y Trigo**) was established in Mexico in 1966 to conduct maize and wheat research for the developing world. Mexico's diverse environment allows researchers to replicate many of the maize and wheat production environments found throughout the developing world.

Some 125 million acres (50 million hectares) are now planted in CIMMYT-developed wheat in developing countries, and there are approximately 32 million acres (13 million hectares) of corn developed by the organization that are under cultivation in those countries.

CIMMYT's current annual budget is $22 million, which is derived from 30 international donors, among them development banks and technical aid agencies. The Center maintains offices in 15 developing countries outside Mexico. It employs 75 senior international staff, two-thirds of whom are located in Mexico.

Some 1,700 senior scientists of 60 nationalities work at the 18 CGIAR centers around the world. CGIAR was founded in 1971 with the aim of improving sustainable agricultural growth in the developing world. It has achieved a number of successes in the past 23 years in food production, economic development, conservation of genetic resources and environmental protection in the developing world.

Concerned about the prospect of widespread food shortages and hunger in Asia, a group of Donors created the Consultative Group on International Agricultural Research (CGIAR) in 1971. It initially grouped four centers and, building on earlier work promoted by the Ford and Rockefeller foundations, led to the widespread adoptions of new varieties of rice, wheat and maize in what became known as the Green Revolution. Over the years, CGIAR grew to a network of 18 centers and expanded its mandate to address ecological issues, including protecting genetic diversity and the enhancement of capacities of national agricultural research institutions. But the primary focus of this evolving agenda remains the promotion of sustainable agriculture for global food security.

CGIAR has a proven track record of excellence and has demonstrated time and time again that it is one of the few consistently high-return investments made by donor agencies in support of agriculture in the poorest countries of the world. The CIMMYT success story recounted in this press release is just one of many, which also include: overcoming the Cassava mealy-bug; miracle rice; and the hairy potato. Less well-known is CGIAR's efforts to reduce drudgery and improve the incomes of poor rural women, as was done in the improvement of Cassava production and marketing in Africa.

Today, CGIAR is partly a victim of its own success. The specter of widespread food shortages has receded, and there is an unwarranted complacency about the future, despite the inevitable population growth of at least a billion people over the next decade, mostly in the poorest parts of the world. Donors, confronting reduced aid budgets, have chosen the easy avenue of reducing their support for international research, so needed by the poorer regions of the world. Yet, the long term nature of agricultural research requires that we invest today to produce more a decade from now, especially for less reliance on fertilizers and pesticides. It is essential that aid agencies rededicate themselves to the long-term view, from which increased support of CGIAR will inevitably follow, as it is one of the most effective tools in the international arsenal to challenge hunger and to promote environmentally sustainable development.

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